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V.

THE CRYSTALLINE STRUCTURE OF THE COAHUILA IRONS.

By Oliver W. Huntington.

Presented October 10, 1888.

In a previous paper on the crystalline structure of iron meteorites,* the author described two cleavage crystals broken from a specimen of the Butcher meteorite (Coahuila), but, from the compact nature and softness of the iron, no further examples of cleavage were at that time obtained. Recently, however, on examining a large number of small sawed slabs of the same iron in the Harvard Collection, one slab was found to be intersected by an angular crack, as shown of actual size in Fig. 1. On taking the slab in the hand, it was found that the two portions could be readily separated by a slight pressure, and the surfaces, though considerably oxidized, showed sharply defined crystal faces extending through the entire thickness of the plate (about six millimeters) and forming angles of about 132° and 90°.

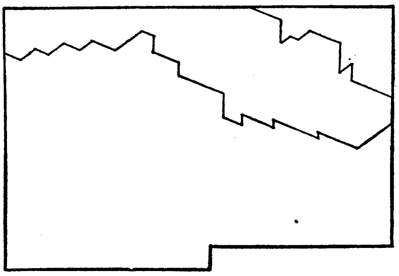

Fig. 1.

As this cleavage was so very striking, an attempt was made to break another slab artificially. It was mounted in a vice for the purpose, and the projecting portion struck with repeated blows of the hammer. The slab broke readily along the jaws of the vice, exhibiting a superb crystalline cleavage, the faces of the crystals having a most brilliant lustre, almost like antimony, and, though the iron was soft enough to cut with a knife, yet some of the single cleavage faces were nine or ten millimeters in extent. These crystal faces usually formed angles of about 132°, or else right angles, though in some parts there were sharp projecting points, formed by the meeting of two rectangular planes with a third set obliquely. Furthermore, all the faces were most beautifully striated by numerous sets of fine parallel lines, easily distinguished by the eye, generally making angles with each other of 127°, 90°, and 53° respectively, a few of the lines appearing to be parallel to the intersections of the faces.

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* American Journal of Science, 3d series, vol. xxxii. pp. 284–303.

Fig. 2 shows enlarged one set of crystal faces as they appeared on the surface of fracture. The planes were absolutely perfect, and large enough to be readily measured with an application goniometer. Thus

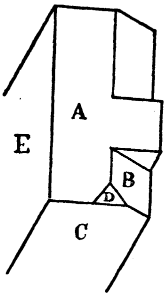

FIG. 2.

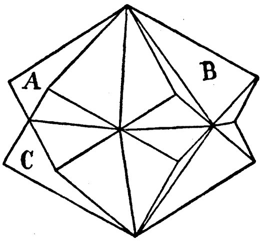

FIG. 3.

it was found that the plane B made with C a right angle, B and A an angle of about 132°, A and C an angle of about 109°; and the small plane D, set obliquely on the solid angle thus formed, made an angle of about 125° with B and C, and 164° with A. The plane E and the one parallel to it were the sawed faces of the slab. All the other planes forming the surface of fracture were parallel to the ones shown in the figure, and they could all be referred to faces of the twin cube, as shown in Fig. 3, where the corresponding faces are lettered the same and placed in a parallel position. The striations already mentioned appeared most markedly on the face A, that being the largest, and therefore the one most easily examined.

Fig. 4 shows, on a large scale, this plane referred to the face of a cube, only the most prominent of the striations being represented, in order to preserve clearness in the figure. It will be seen by the diagram, that all the lines follow the intersections of the different members of an ordinary cube twinned on all of the trigonal axes, and there were no markings on the face which could not be thus referred. However, on examining the triangular face D of Fig. 2, it appeared in marked contrast to the face just described, as all the markings were parallel to the octahedral edges, thus forming simple triangles.

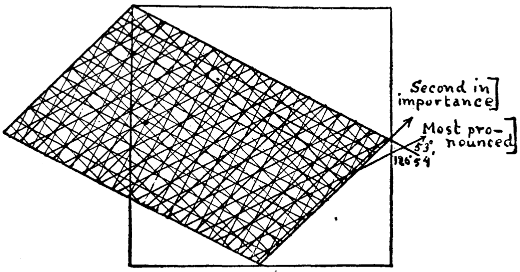

FIG. 4.

A large number of specimens of the Butcher iron were afterwards examined, and they all exhibited the same crystalline cleavage on a fresh fracture. Moreover, it made no difference in what direction the slab was broken, the planes always showed a prevalence of the 132° angle (theoretical angle 131° 48′ 37″), with here and there the sharp projecting points already referred to, but, contrary to expectation, the simple cube angles seldom appeared, though in some parts they were evident.

It now appeared important to examine the cleavage of the Sancha Estate or Saltillo iron (Santa Rosa), which has been considered part of the same meteorite as the Butcher specimens. For this purpose Mr. S. C. H. Bailey sent us a wedge-shaped slab which had been sawed to a thin edge and then broken, giving a surface of fracture about seventy millimeters long and two millimeters wide in the thickest part, diminishing towards the two ends. The crystal faces over this surface were very small, and appeared to have a grayer color than those of the other irons. When this surface was examined under a low power microscope, the crystals were found to be all simple cubes, looking exactly like a specimen of galena, and, instead of the faces being striated as in the Butcher irons, they exhibited the little crystalline projections and depressions which are so characteristic of some alloys. However, on the face of the slab there was the suggestion of two cracks crossing at angles of about 132° and 53°, and an attempt was made to break the specimen parallel to one of these cracks, with the expectation of getting the planes already described in the previous iron.

When the slab was mounted in the vice and struck with the hammer, there at once appeared on the surface numerous very fine cracks parallel to the two directions just mentioned, and at once suggesting the two sets of fine parallel lines which are first brought out on an etched surface of this iron but are obliterated by the continued action of the acid. Finally, the slab broke, but exhibited only a single plane through the entire extent of the fracture (33 mm. in length by 6 mm. in breadth), and, instead of being striated, there was developed a very striking flaky surface as if little thin layers had resisted the cleavage, parting at last with irregular edges more or less separated from the main surface. An attempt was next made to break the slab at right angles to the first direction, in order to get other crystal faces; but, instead of breaking along the edge of the vice, as a Butcher specimen readily would have done, the Saltillo iron broke again with the same single cleavage plane, at right angles to the desired direction and running directly down into the jaws of the vice, entirely regardless of the way it had been clamped and the blows of the hammer applied.

Every attempt to break the slab gave the same result. It would only break in the two directions indicated by the first fine cracks, and corresponding to the angle that a cube face makes with the adjacent face of a twin cube, and always broke along a single plane exhibiting the flaky surface already mentioned. The only way of getting a different fracture was to saw the specimen to a thin edge, and so *force* it to break in the desired direction, and then it would present a surface of fine cubes wholly different in character from the large striated faces of the Butcher irons.

Just at this time we received from Ward and Howell a large slab of a new meteorite found in Allen County, Kentucky, and the whole character of this iron, including the etched surface, so closely resembled the Coahuila specimens that we were interested to see whether it would show any striking cleavage. Ward and Howell kindly furnished us with some small slabs, and, on breaking them in the way already described, they showed exactly the same characters as the Saltillo iron. The fine parallel cracks appeared under the first blows of the hammer, and then the slab broke regardless of the way it was clamped in only the two directions at angles of about 132° and 53°, presenting a single cleavage plane with the marked flaky appearance characteristic of the Saltillo iron.

Exactly the same result was obtained in breaking slabs of the Maverick County[*] iron, and also the iron from Chattooga County, Georgia,[†] both of which were described as independent falls, although closely resembling the Coahuila specimens.

Now it will be borne in mind that the Coahuila irons form a group by themselves, their etched surfaces appearing so markedly different from any other known meteorite, and for this reason, together with a resemblance in composition, they have commonly all been considered to belong to one fall. But, after examining the structure of the Butcher irons and that of the Saltillo or Sancha Estate as exhibited by the cleavage, it is impossible to class them as portions of a single original mass. And, on the other hand, when we compare in the same way the Saltillo iron with those of the Allen County, Chattooga County, and Maverick County meteorites, it seems equally impossible to believe that they did not at one time form a single meteorite, especially when they also resemble each other in composition as shown in the following analyses, though to be sure it is hard to tell how far such analyses can be depended upon as a means for comparison or distinction of irons.

	[‡] Allen Co.	[§] Santa Rosa.	[‖] Maverick Co.	[¶] Chattooga Co.
Iron	94.32.	95.82	94.90	94.60
Nickel	5.01	3.18	By diff. 4.87	4.97
Cobalt	trace	.35		.21
Sulphur	.34	....	....	....
Phosphorus	.16	.24	....	.21
Carbon	.12	....	.23	....
	99.95	99.59	100.00	99.99

That these masses were found in places so remote from each other does not seem to preclude their having belonged to one individual, since the Rochester meteorite was seen to pass over the States of Kansas, Missouri, Illinois, Indiana, Ohio, and is supposed to have passed over Pennsylvania and New York, and thence out to sea, dropping fragments in its course. It therefore is possible that at some remote period an enormous iron meteorite may have passed over the entire breadth of the United States, the main mass reaching Mexico, but large fragments breaking off and falling during its passage across the country.

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[*] Amer. Jour. Sci., 3d series, vol. xxxii. p. 304, October, 1886.

[†] Ibid., vol. xxxiv. p. 471, December, 1887.

[‡] Ibid., vol. xxxiii. p. 500, 1887.

[§] Ibid., 2d series, vol. xix. pp. 160, 161, May, 1855.

[‖] Ibid., 3d series, vol. xxxii. p. 304, October, 1886.

[¶] Ibid., vol. xxxiv p. 472, December, 1887.

Two irons commonly classed under the general head of "Coahuila" have not been included in the above consideration. They are labelled in the Harvard College collection, "Hacienda de Concepcion," * and "San Gregorio Iron, Chihuahua, Mexico," † both bearing the signature of Dr. H. B. Butcher. The specimen of the Hacienda de Concepcion was small, and had been hammered, so that its structure could not be conclusively studied, but it appeared to be markedly different from any of the other Mexican irons.

The San Gregorio iron, of which there were numerous specimens, appeared to be made up of very striking octahedral plates, and therefore must be placed among a very different class of irons from the Coahuila group, which it has been the purpose of this paper to describe.

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* Amer. Jour. Sci., 2d series, vol. xix. p. 163, 1855.

† Ibid., 3d series, vol. ii. p. 336, 1871.